Florida Power & Light Company, 6501 S. Ocean Drive, Jensen Beach, FL 34957

February 18, 2004

L-2004-034
10 CFR § 50.73

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C. 20555

Re: St. Lucie Unit 2
Docket No. 50-389
Reportable Event: 2003-005-00
Date of Event: December 20, 2003
Automatic Reactor Trip Due to Loss of Turbine Generator Excitation

The attached Licensee Event Report 2003-005 is being submitted pursuant to the requirements of 10 CFR § 50.73 to provide notification of the subject event.

Very truly yours,

William Jefferson, Jr.
Vice President
St. Lucie Nuclear Plant

WJ/KWF
Attachment

IE22

NRC FORM 366 (7-2001) U.S. NUCLEAR REGULATORY COM

APPROVED BY OMB NO. 3150-0104 EXPIRES 7-31-2004

Estimated burden per response to comply with this mandatory information collection request: 50 hrs. Reported lessons learned are incorporated into the licensing process and fed back to industry. Forward comments regarding burden estimate to the Records Management Branch (T-6 F33), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, and to the Paperwork Reduction Project (3150-0104), Office of Management and Budget, Washington, DC 20503. If an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
St. Lucie Unit 2	05000389	Page 1 of 5

TITLE (4)

Automatic Reactor Trip Due to Loss of Turbine Generator Excitation

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
12	20	2003	2003	- 005 -	00	02	18	2004	FACILITY NAME	DOCKET NUMBER

[redacted]	1
POWER LEVEL (10)	100

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)

	20.2201(b)		20.2203(a)(3)(ii)		50.73(a)(2)(ii)(B)		50.73(a)(2)(ix)(A)
	20.2201(d)		20.2203(a)(4)		50.73(a)(2)(iii)		50.73(a)(2)(x)
	20.2203(a)(1)		50.36(c)(1)(i)(A)	X	50.73(a)(2)(iv)(A)		73.71(a)(4)
	20.2203(a)(2)(i)		50.36(c)(1)(ii)(A)		50.73(a)(2)(v)(A)		73.71(a)(5)
	20.2203(a)(2)(ii)		50.36(c)(2)		50.73(a)(2)(v)(B)		OTHER
	20.2203(a)(2)(iii)		50.46(a)(3)(ii)		50.73(a)(2)(v)(C)		Specify in Abstract below or in NRC Form 366A
	20.2203(a)(2)(iv)		50.73(a)(2)(i)(A)		50.73(a)(2)(v)(D)		
	20.2203(a)(2)(v)		50.73(a)(2)(i)(B)		50.73(a)(2)(vii)		
	20.2203(a)(2)(vi)		50.73(a)(2)(i)(C)		50.73(a)(2)(viii)(A)		
	20.2203(a)(3)(i)		50.73(a)(2)(ii)(A)		50.73(a)(2)(viii)(B)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
Kenneth W. Frehafer, Licensing Engineer	(772) 467 - 7748

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX		CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX
X	TL	90	W120	YES		-	-	-	-	-

[redacted]

				EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
	YES (If yes, complete EXPECTED SUBMISSION DATE).	X	NO				

ABSTRACT *(Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines)* (16)

On December 20, 2003, St. Lucie Unit 2 was in Mode 1 at 100 percent power. At 0948 hours St. Lucie Unit 2 automatically tripped from full power on loss of generator field current. Except for the overspeed trip of the 2C turbine-driven auxiliary feedwater pump, the plant trip response was uncomplicated as all safe shutdown equipment operated as designed. There were no human performance issues associated with the trip.

Vendor assisted troubleshooting efforts identified that the failure of the main generator voltage regulator current regulator instant limiter module was the most likely root cause the December 20, 2003 trip. St. Lucie Unit 2 was returned to full service on December 28, 2003.

The faulty module was replaced, and a temporary multi-channel recorder was installed to monitor key areas of the main generator automatic voltage regulator circuitry. This monitoring equipment will remain installed until the fall 2004 refueling outage.

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
St. Lucie Unit 2	05000389	2003	- 005	- 00	Page 2 of 5

TEXT *(If more space is required, use additional copies of NRC Form 366A)* (17)

Description of the Event

On, December 20, 2003, St. Lucie Unit 2 was in Mode 1 at 100 percent power. At 0948 hours St. Lucie Unit 2 automatically tripped from full power on loss of generator field current. Based on the data from the plant's digital fault recorder (DFR), which relays digital and analog generator data to Transmission Operations, main generator exciter field current went to zero for approximately 3.5 seconds before the unit trip. When the exciter field current was lost the main generator field began to collapse. The loss of generator field (LOF) protective relay actuated, actuating the main generator back-up lockout relay that tripped the turbine and the reactor. The operator performed standard post-trip actions and stabilized the plant in Mode 3. Auxiliary feedwater (AFW) automatically actuated, but the 2C turbine-driven (TD) AFW pump [EIIS:BA:P] tripped on mechanical overspeed approximately 40 seconds later. All other safe shutdown equipment operated as designed. There was no impact on Unit 1 operation or equipment.

The trip resulted in switchyard voltage transient from a nominal 240 KV to a minimum of 220.7 KV and a maximum of 253.7 KV. This switchyard voltage transient resulted in a momentary degraded voltage condition on the 2A2, 2A5, 2B2, 2B5 480V load centers, tripping the 2D instrument air compressor, the 2A spent fuel pit cooling pump, the 2A hold up tank pump, the 2A closed blow down cooling pump, the continuous tube cleaning recirculation pumps, and several radiation monitor pumps. However, it was not sufficient to engage the undervoltage and degraded voltage relays that would have started and loaded the emergency diesel generators (EDGs). All of the affected pumps were restarted with no issues. Additionally, the power transient caused a spurious radiation monitor actuation that started the shield building vent fan and realigned the ventilation system to the fuel handling building.

Troubleshooting activities initially identified intermittent operation of the Instantaneous Current Limiter Module #2 (ICL #2) in the excitation switchgear voltage regulator circuitry [EIIS:TL:90] as the most likely cause of this event. It was replaced and follow-up testing was completed. Unit 2 was returned to full power during the early morning hours on December 25, 2003 with a multi-channel data capture type recorder temporarily installed to monitor key areas of the automatic voltage regulator circuitry.

At 0948 hours on December 25, 2003, a second loss of main generator exciter field current transient occurred. The digital fault recorder (DFR) captured this second event. Its duration was 1 second and was not long enough to lock in the LOF relay logic, therefore, it did not result in a plant trip compared to the 3.5-second event of December 20, 2003. Unit 2 was operated at reduced power throughout the remainder of December 25, 2003 to collect data from the temporarily installed multi-channel recorder. However, the temporary recorder had not triggered as desired and did not provide data as to the root cause of this second event. A conservative decision was made to bring Unit 2 off-line on December 26, 2003 to allow further testing and repairs.

After consultation with the excitation system vendor, selected critical components associated with the automatic exciter voltage regulator controls, whose failure could cause a loss of exciter field current, were replaced. Eleven components consisting of nine electronic modules and two relays were replaced. The multi-channel recorder was tested, repaired and the trigger points adjusted to capture future events. On December 28, 2003, Unit 2 was returned to service using the automatic voltage regulator circuitry until Unit 2 reached 100 percent power. The voltage regulator was

then switched to the test mode. In the test mode the voltage regulation of the generator is performed manually by Operations personnel making periodic adjustments from the Control Room to match system requirements. The automatic modules remain energized and capable of being recorded, but do not control exciter field current.

The installed recorder has triggered several times since returning Unit 2 back to full power operation. All of the captured events have been caused by normal power system operation (grid) or by noise generated by the exciter field ground detector. None of these captured events have identified any failure that would have caused the events on December 20, 2003 and December 25, 2003.

The electronics modules removed from the automatic voltage regulator circuits were delivered to the vendor for testing to determine if there are any failed components that would explain the events that have occurred.

The main generator rotor field current is supplied by the excitation system. The excitation system consists of the permanent magnet generator (PMG) and exciter, which are coupled to the generator shaft, and the excitation switchgear, which provides control. The excitation system supplies the DC current necessary to set up a magnetic field in the main generator rotor. In automatic mode the AC regulator controls the magnetic field in the main generator rotor to maintain the main generator output voltage at the demand setting of the AC voltage regulator adjuster. When operated in the test mode, the DC regulator maintains a constant current to the exciter field at the demand setting of the DC regulator adjuster. While the AC control circuits are not controlling in the test mode, they are active and responsive to system conditions. The difference between the operating point established by the DC control and where the AC circuits want to take the unit shows up on the balance meter.

The AC voltage regulator logic circuits contain all the equipment necessary to regulate, limit, and compensate the AC voltage regulator signal to the firing circuit. The purpose of the AC voltage regulator logic circuits is to monitor the output of the main generator and use the information to control the excitation. The modules that make up the logic circuit perform a variety of different regulating, compensating, limiting, and protection functions. These limiting and protective features are designed to protect the main generator components from excessive heating which could result in insulation damage for a given gas pressure, power factor, and load being carried by the machine.

Cause of the Event

Following the trip on December 20, 2003, a detailed fault matrix was developed to identify and evaluate all potential causes of the loss of exciter field current as well as troubleshooting and testing required to validate the conclusions. A voltage regulator failure was determined to be the most likely cause as an exciter stator winding open circuit, PMG failure, and excitation supply breaker trip were ruled out.

There are several failure mechanisms within the voltage regulator that could result in loss of exciter field current including: loss of demand signal to the firing circuits, firing circuit malfunction, and power amplifier malfunction. The voltage regulator low power and high power circuits and modules were tested successfully, and relay contact resistance and ground checks, fuse ferrule and socket inspections, and wiring connection inspections did not identify any anomalies.

Based on the complexity of the components, circuitry, and the potential that the testing did not envelop full load on-line conditions, the voltage regulator controls

were still considered to be the most likely suspect. Therefore, FPL made the decision to connect a recorder to the critical parameters and monitor operation during startup and capture data based on a trigger parameter (exciter field current).

During connection and testing of the recorder signals, ICL #2 did not respond to test signals that would ultimately drive the exciter field current to zero. Based on this discovery, FPL concluded that the most probable cause for the loss of exciter field current was intermittent failure of the ICL #2.

Following the second December 25, 2003 event, those components associated with the automatic exciter voltage regulator controls whose failure could cause a loss of exciter field current were replaced. The removed electronic modules were tested at the vendor's test facility with the following conclusions:

1. The ICL #2 module had an intermittent poor contact of one of its internal power supply fuses. It appeared a light coat of clear varnish, applied to the circuitry during the manufacturing process, had coated the exposed portions of the fuse. When the fuse was removed and reinstalled or rotated in position during initial troubleshooting, the varnished contact acted as an insulator between the fuse clips and the fuse contact. This condition resulted in an internal power supply failure at the vendor's facility. This was not the cause of the events of December 20 or 25, 2003 since the module initially tested satisfactorily (internal power supply specifically tested) following the Unit 2 trip of December 20, 2003 and had been removed prior to the December 25, 2003 event.
2. The Current Regulator portion of the Current Regulator/Instant Limiter module was found with an intermittent output signal. This module measures the excitation in the generator and provides an output when the excitation exceeds a preset value. This module also includes a timer function to momentarily allow the excitation to exceed the limit (forcing). Intermittent failure of the output in the high direction would drive exciter field current low. If failed, the output would provide a signal that would have led to the events of December 20 and December 25, 2003.

Failure of the Current Regulator/Instant Limiter module is most likely the root cause of one or both of these events. Subsequent investigation of the December 25, 2003 event led to the discovery that a coincident 20 MW electrical grid disturbance had occurred that may have contributed to that event.

Based on discussions with the vendor, no change in preventative maintenance practices could predictably prevent an isolated intermittent failure of a single integrated circuit. Wholesale replacement of all circuitry on a periodic frequency would likely introduce more problems than it eliminates due to infant mortality of components. Therefore, no new or additional maintenance procedures need to be added to address voltage regulator components due to aging concerns. FPL procedure 0-EMP-53.09 "Main Generator Voltage Regulator and Excitation Switchgear Testing and Maintenance," which is performed every refueling outage, is the most efficient method to sufficiently identify any potential problem.

Analysis of the Event

This event is reportable under 10 CFR 50.73(a)(2)(iv)(A) as any event or condition that resulted in the automatic actuation of the reactor protection system (RPS).

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
St. Lucie Unit 2	05000389	2003	- 005	- 00	Page 5 of 5

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Analysis of Safety Significance

Reactor trips are analyzed events. Except for the overspeed trip of the 2C TDAFW pump, all other safe shutdown equipment operated as designed. The momentary degraded voltage had no effect on safety-related safe shutdown equipment, and the equipment affected was readily recovered. The spurious radiation alarms and actuations resulted in the affected ventilation systems operating in their fail-safe mode. Additionally, there were no human performance issues associated with the Unit trip. Therefore, the health and safety of the public were not adversely affected by this event.

The Unit 2 St. Lucie exciter switchgear is a Westinghouse model WTA-300 High Initial Response (HIR) Brushless Excitation System. This system is employed by St. Lucie Unit 1 and is susceptible to the same exciter switchgear failures encountered during this St. Lucie Unit 2 event. However, continued testing and calibration checks of the voltage regulator modules each refueling outage is adequate and no periodic component or sub-component replacements are recommended by the vendor.

Corrective Actions

1. The faulty voltage regulator module was replaced.
2. FPL will continue monitoring and evaluating the chart recorder output until the fall 2004 St. Lucie Unit 2 refueling outage (SL2-15).

Additional Information

The 2C TDAFW Pump mechanical overspeed trip issues are covered in detail in LER 50-389/2003-006-00, "Long-Standing 2C TDAFW Pump Design Issue Resulted in Condition Prohibited by Tech Specs."

Failed Components Identified

Component: WTA-300 High Initial Response (HIR) Brushless Excitation System (Voltage Regulator)

Manufacturer: Westinghouse (now Eaton Cutler Hammer)

Model Number: WTA-300 HIR

Similar Events

None